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Summary of a Report on the Concentrations of Mercury, PCBs and Uranium from Upper East Fork Poplar Creek and Environs

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A short-term study was conducted in June of 1983 to evaluate the concentrations of mercury, uranium, and polychlorinated biphenyl (PCB) in selected biota from several sites in the vicinity of upper East Fork Poplar Creek (EFPC). Edible portions of the biota were analyzed for total mercury, PCBs seven Aroclor species (1016, 1221, 1232, 1242, 1248, 1254 and 1260), and three isotopes of uranium (^{238}U, ^{235}U, and ^{234}U).

Fish collected from South Hills Golf Course Pond, Scarboro Pond, and lower Tuskegee Creek had concentrations of total mercury less than the current FDA's "action level" (1.0 μg/g). Mercury levels in bluegill from the two ponds were similar and were approximately 20 to 30% of the FDA limits. The mean concentration of mercury in largemouth bass from Scarboro Pond was approximately double that in bluegill but was still less than 50% of the FDA limit. Fish collected from lower Tuskegee Creek had a maximum mercury concentration of 0.56 μg/g. Although the exact source of this contamination to the fish is unknown, it is likely that fish from EFPC move in and out of the lower reaches of Tuskegee Creek.

In addition to fish, other biota were found to have elevated levels of mercury. Levels of mercury above 1.0 μ g/g were found in samples of bullfrogs from upper EFPC. Low mercury concentrations were observed in bullfrogs from South Hills Gold Course and Scarboro Pond; however, most of the individuals were small. High mercury concentrations were also found in crayfish collected from the upper reach of EFPC. The levels ranged from 2.20 to 3.05 μg/g total mercury, which is similar to the levels reported for bluegill from this reach of the stream.

The mean concentration of PCBs (Aroclor 1254) in bluegill collected from South Hills Golf Pond (1.9 μ g/g) was just below the proposed FDA tolerance level of 2 μg/g in fish. The maximum concentration was 3.89 μg/g, fresh weight. These levels exceeded those found in bluegill from the upper reach of EFPC between New Hope Pond and Bear Creek. Elevated levels were also found in the single turtle collected from South Hills Golf Course Pond, but concentrations in small bullfrogs from this pond were below the detection limit of 0.01 μg/g. Very low PCB concentrations, predominantly Aroclor 1260, were found in largemouth bass from Scarboro Pond; however, because PCBs do not occur naturally, any detectable level is an indication of contamination.

Sixteen samples were analyzed for isotopes of uranium. Because of the sample size required for isotopic analysis (50 g), many of the fish and frog samples were composite samples. The concentration of the isotopes of uranium appears to be relatively low. In all but three samples, the concentration of the uranium isotopes ^{234}U and ^{236}U indicated that

the isotopes were not in equilibrium with ^{238}U. In other words, the uranium is not from a natural source but appears to be enriched in ^{234}U and ^{235}U as a result of human activities.

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PRELIMINARY REPORT OF THE CONCENTRATIONS OF MERCURY, PCBs, AND URANIUM IN AQUATIC ORGANISMS FROM UPPER EAST FORK POPLAR CREEK AND ENVIRONS

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1. INTRODUCTION

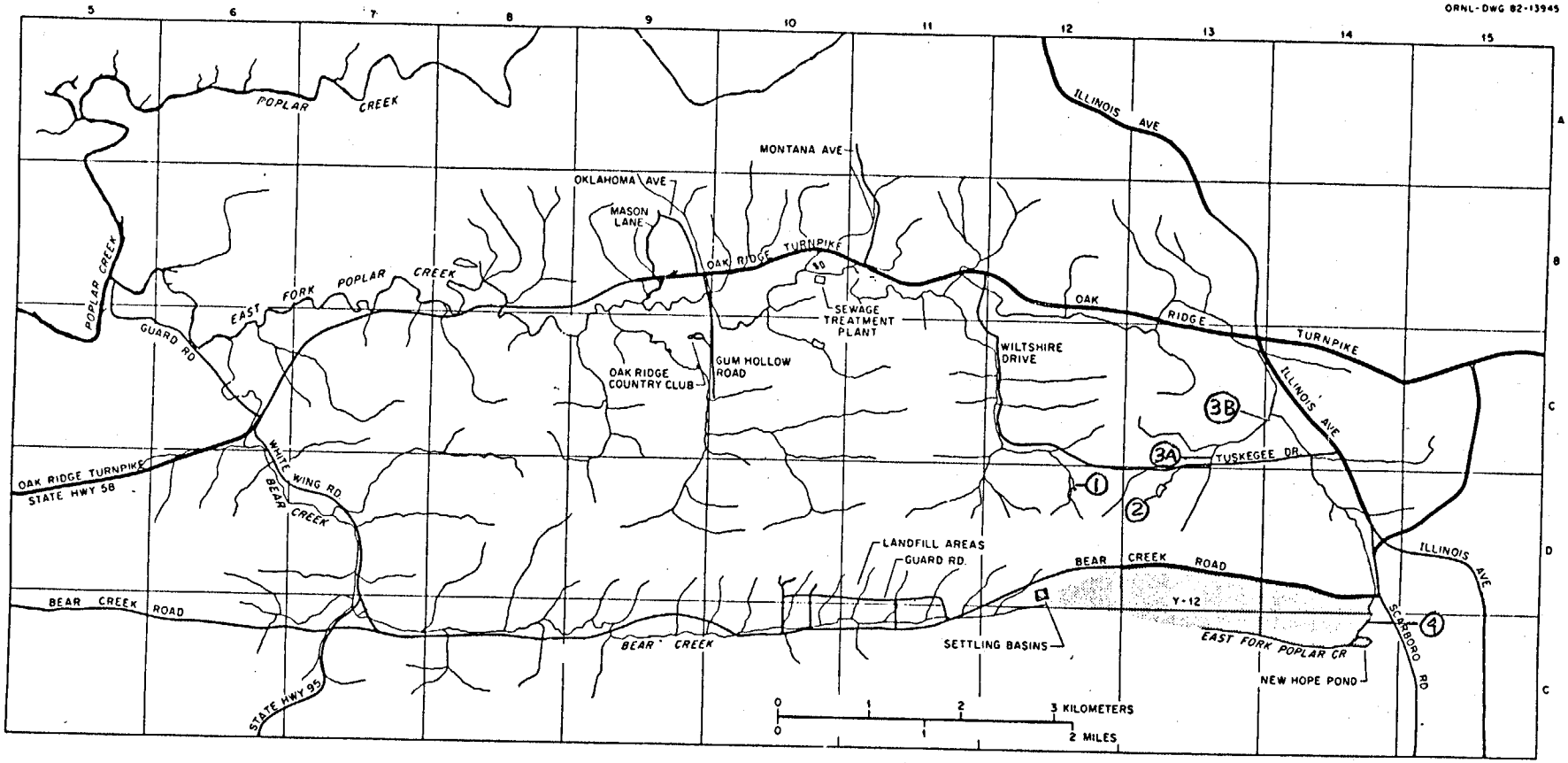
At the request of the Y-12 Department of Health, Safety, and Environment, the Environmental Sciences Division at Oak Ridge National Laboratory (ORNL), with assistance from the Analytical Chemistry Division (ACD), conducted a short-term study to evaluate the concentrations of mercury, uranium isotopes (^{234}U, ^{235}U, and ^{238}U), and polychlorinated biphenyl (PCB) contamination in selected biota from several sites in the vicinity of upper East Fork Poplar Creek (EFPC) north of the Y-12 Plant. The design of the study, including the contaminants and biota to be analyzed, sampling sites, and sample numbers, was provided by the Y-12 staff on June 9, 1983. Sample collections, laboratory analyses, and data evaluation/interpretation were conducted under the constraint that all work was to be completed and a report submitted by June 20, 1983.

2. METHODS

Sample Collection

Biota were sampled at four sites near the upper reaches of East Fork Poplar Creek (EFPC) on June 9-11, 1983 (Fig. 1). The study design, as initially proposed, was modified to include an additional site (designated Station 3B in Fig. 1) on lower Tuskegee Creek to determine the extent of contamination in fish that may migrate up this creek from EFPC. Attempts were made to collect frogs and turtles from each of the four sites (excluding station 3B) and to collect fish from all sites except EFPC (Station 4), which was sampled previously by Van Winkle et al. (1982). Crayfish were added to the original list of

Fig. 1.



South Hills

Fig. 1. Location of sampling sites. 1 = Golf Course Pond; 2 = Scarboro Pond; 3A = Upper Tuskegee Creek; 3B = Lower Tuskegee Creek; 4 = East Fork Poplar Creek. Types of samples collected at each site are listed in Table 1.

biota because of their close affinity with the sediments and their possible inclusion in the diet of some Oak Ridge residents. Crayfish were collected from Station 4 (EFPC) on June 13–14, 1983. A summary of the biota collected from each sampling site is presented in Table 1.

Although considerable effort was expended in an attempt to obtain adequate samples of biota from each site (Table 2), constraints on the time available for sampling resulted in small sample sizes at some sites. Despite additional sampling on June 13–15, 1983, the number of turtles collected was very small and only at one site (Station 3a) were two individuals collected. To obtain an adequate sample would require substantially greater time and effort than was possible in a short-term study of this nature. In some cases, however, the habitat at the site did not support large populations from which an adequate sample could be collected. Frogs were not abundant in Scarboro Pond (Station 2), and fish that would be utilized for food by local residents were not found in upper Tuskegee Creek (Station 3A). Interpretation of results that are based on such small samples sizes (e.g., one or two individuals) is difficult, and any conclusions regarding risk to the public would be inappropriate. The sampling effort that was expended in this study (Table 2) was the maximum possible in view of the time required for laboratory analyses and report preparation.

Sample Analyses

Biota collected from each sampling site were placed in plastic bags and stored on ice. Samples were returned to the laboratory and either processed immediately or stored in a refrigerator and processed the following day. All fish were identified to species, weighed to the

Table 1

Table 1. Location, site description, and type of sample taken for sampling sites in the vicinity of upper East Fork Poplar Creek. X = sampled, NS = not sampled; NC = sampled, but no organisms found

Sampling site[a]	Site description	Grid quadrant[b]	Type of sample collected			
			Fish	Frogs	Turtles	Crayfish
1	~0.5-ha pond on South Hills Golf Course, including 50 m below pond outlet	D-12	X	X	X	NS
2	~0.5-ha pond just west of Scarboro community	D-13	X	X	NC	NS
3a	Upper Tuskegee Creek, approximately 50 m above and 100 m below bridge on Tuskegee Drive	C-13	X	NC	X	NS
3b	Lower Tuskegee Creek, approximately 20 m above confluence with East Fork Poplar Creek to transmission line crossing	C-13,14	X	NS	NS	NS
4	East Fork Poplar Creek between New Hope Pond and bridge on Tulsa Avenue	C,D,E-14	NS	X	X	X

[a]Location shown on Fig. 1.

[b]Map S-16A, Oak Ridge area (Tennessee Valley Authority 1974).

Table 2. Collecting methods and sampling effort at the four sampling sites in the vicinity of upper East Fork Poplar Creek[a]

Biota	Sampling methods	Total time (h)					Effort (man-h)				
		GCP	SP	UT	LT	EFPC	GCP	SP	UT	LT	EFPC
Fish	Electroshocking (boat)	1.0	1.0	-	-	-	3.0	3.0	-	-	-
	Electroshocking (backpack)	0.5	-	0.8	0.8	-	1.00	-	2.2	1.5	-
	Angling	-	1.50	-	-	-	-	3.0	-	-	-
	Trotline (30 m)	-	0.8	-	-	-	-	1.5	-	-	-
Frogs	Gigging	1.5	1.0	-	-	2.0	7.5	3.0	-	-	8.0
	Grab sampling	-	-	-	-	1.8	-	-	-	-	2.2
Turtles	Grab sampling	0.5	0.5	1.5	-	-7.5	1.5	1.0	3.5	-	11.0
	Trapping[b]	2.0	2.0	-	-	18.0	-	-	-	-	
Crayfish	Grab sampling	-	-	-	-	1.0	-	-	-	-	3.0

[a]GCP = Golf Course Pond; SP = Scarboro Pond; UT = Upper Tuskegee Creek; LT = Lower Tuskegee Creek; EFPC = East Fork Poplar Creek.

[b]Values refer to number of trap nights.

Table 2

nearest 0.1 g (fresh wt), and measured (total length) to the nearest 0.1 cm. A stainless steel fillet knife was used to remove most of the axial muscle and separate it from the skin. Frogs were weighed to the nearest 0.1 g and the bone, skin, and foot were removed from each leg before analyzing the tissue. Turtles were weighed to the nearest gram and the muscle in the legs and neck was removed. Crayfish were weighed to the nearest 0.1 g and the muscle in the tail was removed.

Approximately 10 g of muscle were taken for each of the mercury and PCB analyses, and 50 to 75 g of muscle were analyzed for uranium. To obtain sufficient sample weights, crayfish were composited (3–6 individuals per sample) for mercury and PCB analyses; frogs and smaller bluegill of similar size were composited for uranium and, in one case, mercury. Samples of muscle tissue were placed in labelled vials for mercury and PCB analyses and in plastic bags for uranium analyses and sent directly to the Analytical Chemistry Division at ORNL for analyses. All remaining carcasses were placed in labelled plastic bags and frozen.

All analyses were conducted by ACD staff using the procedures outlined by Weber et al. (1977). Only total mercury analyses are reported for the biota. Because of the time constraints, organic mercury analyses are not included in this preliminary report.

3. RESULTS AND DISCUSSION

Mercury

None of the fish collected from South Hills Golf Course Pond, Scarboro Pond, and lower Tuskegee Creek had concentrations of mercury in muscle that exceeded the current "action level" for mercury in fish (Table 3). The "action level" of 1.0 µg/g is recommended by the U.S. Food

Table 3

Table 3. Mean concentration (±1 SE) total mercury in muscle tissue of biota from various habitats in the vicinity of upper East Fork Poplar Creek

Site/species	Sample size (n)	Mean weight (g)	Total mercury concentration (µg/g, fresh wt) Mean (±1 SE)	Range
Golf Course Pond (Station 1)				
Bluegill	9	81.0[a]	0.29±0.04[b]	0.17-0.60
Bullfrog	7	54.2	0.13±0.04	0.051-0.38
Eastern painted turtle	1	425.	0.056[c]	-
Scarboro Pond (Station 2)				
Bluegill	4	91.9	0.22±	0.20-0.24
Largemouth bass	8	177.3	0.42±0.05	0.28-0.74
Bullfrog	2	54.4	0.027±0.01	0.023-0.031
Tuskegee Creek (Station 3)				
Upper Tuskegee Creek (Station 3a)				
Snapping turtle	2	2438.	0.09±0.04	0.058-0.12
Lower Tuskegee Creek (Station 3b)				
Central stoneroller	1	15.0	0.16	-
Creek ~~club~~ chub	3	38.6	0.16±0.03	0.10-0.20
Red breast sunfish	2	63.4	0.44±0.12	0.31-0.56
East Fork Poplar Creek (Station 4)				
Bullfrog	10	216.1	0.60±0.13	0.17-1.22
Snapping turtle	1	406.	0.46[c]	-
Crayfish	3[d,e]	12.0	2.50±0.27	2.20-3.05
	1[d,f]	14.4	0.92	-

[a]Includes a bluegill x Lepomis sp. hybrid that weighed 395.2 g; excluding this individual, mean wt = ~~41.8~~ g and range = 29.5-67.8 g.

[b]Does not include a 107.6-g bluegill collected from stream just below outlet of pond (mercury concentration = 0.81 µg/g, fresh wt).

[c]Mean of two replicates.

[d]Composite samples.

[e]Collected near East Fork Poplar Creek Mile (EFPCM) 13.8.

[f]Collected near EFPCM 12.3.

Table 4

Table 4. Unadjusted and adjusted (normalized) mean concentration (±1 SE) of total mercury in muscle tissue of bluegill and largemouth bass from two contaminated sites and an uncontaminated reservoir (Melton Hill). Range is given in parentheses. The mean concentration of mercury in fish from both ponds and bluegill in Melton Hill Reservoir was adjusted by computing the concentration in a 63-g bluegill and 150-g largemouth bass using the regression equations presented in footnotes. N/A = Data not presented in Elwood (1977)

Species/sites	Mean weight (g)	Total mercury concentration (µg/g, fresh wt)	
		Unadjusted mean	Adjusted mean
Bluegill			
Golf Course Pond	81.0	0.29±0.04 (0.17-0.60) n=9	0.29(0.25-0.34)[a,b]
Melton Hill Reservoir			
Loar (1981)	89.7	0.061±0.010 (0.031-0.077) n=10	c
Elwood (1977)	N/A (~Range:10-100)	0.05±0.01 (<0.01-0.08) n=18	0.03[d](N/A)
Largemouth bass			
Scarboro Pond	177.3	0.42±0.05 (0.28-0.74) n=8	0.43(0.38-0.50)[a,e]
Melton Hill Reservoir[f]	N/A	0.02±0.01 <0.01-0.05 n=11	g

[a]95% confidence interval on the estimated concentration in parentheses.

[b]$Log_{10}Y = -1.2606 + 0.4018\ log_{10}X$ where Y = total mercury concentration in µg/g, fresh wt and X = fish weight in g; $R^2 = 0.75$; Pr>F = 0.003.

[c]Regression coefficient not significantly different from zero (Pr>F = 0.75).

[d]$lnY = -6.30 + 0.71\ lnX$, where X and Y are defined in footnote 'b,' slope >0 for $P < 0.10$.

[e]$Log_{10}Y = -0.9598 + 0.2742\ log_{10}X$; $R^2 = 0.75$; Pr>F = 0.005.

[f]From Elwood (1977).

[g]Slope of regression not significantly different from zero ($P > 0.10$).

and Drug Administration (FDA). Levels in bluegill from the two ponds were similar and were approximately 20 to 30% of the FDA limit. The mean concentration of mercury in largemouth bass from Scarboro Pond was approximately double that of bluegill but still less than 50% of the FDA limit. The highest level (0.81 µg/g) in any single fish was found in a bluegill collected in the small stream just below the outlet of South Hills Golf Course Pond. Additional sampling should be conducted to determine whether this single sample is representative of the population in the stream.

Although the mercury concentrations in fish did not exceed the FDA "action level," levels exceeded those generally found in fish from uncontaminated sites (Table 4). Because mercury levels in fish axial muscle are related to the age, as reflected by weight, of the fish (i.e., older fish have had a longer exposure to the contaminant and more time to accumulate it), comparisons between sites require adjustment of the mercury data to account for any differences in weight ranges of the fish between the contaminated and uncontaminated sites. A regression analysis of mercury concentration on fish weight was computed for those species and sites where n5 (i.e., bluegill in South Hills Golf Course Pond and largemouth bass in Scarboro Pond). Because of the wide range in fish weight at several sites, the mercury and weight data were log transformed. The resulting log-log regression equation was used to adjust the mercury values to the concentration in a 63-g bluegill, as suggested by Van Winkle et al. (1982), and in a 150-g largemouth bass. Although these weights are somewhat arbitrary, they

are representative of the minimum sizes of fish that a fisherman is likely to keep and eat.

The results of the analysis are presented in Table 4. Although the analysis assumes that fish from the different sites have similar growth rates, sufficient time was not available to obtain the necessary data to examine this assumption. Nevertheless, the results indicate that the concentrations found in the present study exceeded the background levels reported for fish from Melton Hill Reservoir, a site with no known sources of mercury contamination. Thus, bluegill and largemouth bass from South Hills Golf Course and Scarboro ponds, respectively, are contaminated with mercury.

New evidence of mercury contamination was also found in the fish collected from lower Tuskegee Creek (Fig. 1). Although the exact source of this contamination to the fish is unknown, it is likely that fish from East Fork Poplar Creek move in and out of the lower reaches of Tuskegee Creek because no barriers exist to prevent such localized movements. How far upstream these fish actually "migrate" is unknown. Sampling in both lower and upper Tuskegee Creek indicated similar fish communities in the two reaches and very low numbers of those species (e.g., sunfishes) that might be taken by fishermen.

In addition to fish, other biota were also found to have elevated levels of mercury. Although low mercury concentrations were observed in the bullfrogs from South Hills Golf Course and Scarboro ponds, most of the individuals were small. Analyses of mercury in frogs from upper EFPC suggest that the increasing concentration of mercury with weight/age often found in fish may also occur in frogs (Table 5). A

Table 5

South Hills

Table 5. Unadjusted and adjusted (normalized) mean concentration (±1 SE) of total mercury in muscle tissue of bullfrogs collected from Golf Course Pond (Station 1) and East Fork Poplar Creek (Station 4). Range is given in parentheses. The mean concentration at Station 4 was adjusted by computing the concentration in a 68-g frog using the regression equation in footnote 'a'

Site	Mean weight (g)	Total mercury concentration (µg/g, fresh wt)	
		Unadjusted mean	Adjusted mean
South Hills Golf Course Pond	54.2	0.13±0.04 (0.051-0.38) n=7	b
East Fork Poplar Creek	216.1	0.60±0.13 (0.17-1.22) n=10	0.18(0.09-0.36)a,c

[a]$Log_{10}Y = -2.4932 + 0.9557 \log_{10}X$, where Y = total mercury concentration in µg/g, fresh wt and X = frog weight in g; $R^2 = 0.64$ and $P > 0.006$.

[b]Regression coefficient not significantly different from zero ($P > F = 0.60$).

[c]95% confidence interval on the estimated concentration in parentheses.

significant log-log regression of total mercury concentration against frog weight was found at this site, the only one where individuals were collected over a broad size range. Additional samples of larger frogs and sediment samples from the two ponds are needed to obtain an accurate estimate of the extent of mercury contamination at these sites. Although the mercury levels in larger frogs from East Fork Poplar Creek exceeded 1.0 µg/g, no guidelines exist for mercury levels in biota other than fish and poultry.

High mercury concentrations were also found in crayfish collected from the same reach of EFPC (Table 3). The levels are similar to those reported by Van Winkle et al. (1982) for bluegill in upper East Fork Poplar Creek. Sediments in the creek are a sink for mercury discharged via New Hope Pond and are a source to biota, such as crayfish, ~~which~~ that live in close proximity to the substrate. If most of the total mercury in frogs and crayfish is methylmercury, then these organisms pose a similar risk ~~as~~ to that for fish to humans that consume them. According to Bryne et al. (1975), frogs near a mercury mine contained virtually 100% methylmercury in their muscles. Because of time constraints, no analyses of organic mercury were reported for any of the organisms. Such analyses are necessary to determine the percentage of methylmercury in frogs and crayfish; ~~although, however, many studies have shown~~ but it is generally accepted that approximately 95% of the mercury in fish is methylmercury.

Too few samples were collected to adequately determine mercury levels in muscle tissue of turtles at the various sites and, in turn, to assess the potential risk to residents who consume them. Although numerous investigators have reported significant positive correlations

between mercury concentration and size (or age) in fish, less is known about mercury accumulation in other aquatic biota, particularly reptiles and amphibians. While the levels found in the few turtles collected in the present study are low, additional sampling should be conducted to include individuals of a broad range of sizes/ages. Because the highest concentration of mercury (0.46 µg/g) was found in the relatively small turtle (from upper EFPC), it is possible that larger turtles from the same area may have significantly higher levels of mercury.

PCBs

Polychlorinated biphenyls (PCBs) were produced commercially in the United States by the Monsanto Chemical Company under the trade name Aroclor. They are actually mixtures of chlorinated biphenyl isomers and were used primarily as insulating fluids for transformers and capacitors. A given mixture (or Aroclor species) is identified by a four-digit number, the last two digits of which refer to the percentage of chlorine, by weight, in the mixture. Samples of biota from the four sampling sites were analyzed for the following Aroclor species: 1016, 1221, 1232, 1242, 1248, 1254, and 1260. Typically one predominates with others present in levels below the detection limit.

Most of the PCBs currently manufactured in the United States are mobile oils and are characterized by a low solubility in water. In general, the solubility in water decreases with an increase in the percentage by weight of chlorine in the mixtures. Because PCBs tend to be adsorbed to particulate matter, their accumulation in river and lake

sediments results in concentrations that greatly exceed the concentrations in the water column. Accumulation in biota can occur through direct uptake from water or from the food chain.

In 1979, the FDA issued a final regulation reducing tolerances for PCBs in several classes of foods [Fed. Regist. 44(127): 38330–38340, June 29, 1979]. Although the tolerance level for PCBs in fish and shellfish was lowered from 5 to 2 µg/g, the effective date of this provision of the regulation was stayed, pending resolution of the issues raised in an objection and request for formal hearings submitted by the National Fisheries Institute [Fed. Regist. 44(195): 57389, October 5, 1979]. Because no objections and hearing requests were received in other provisions of the regulation (revised tolerances for PCBs in milk, dairy products, poultry, and eggs), these revisions went into effect, as scheduled, on August 28, 1979. Hearings were announced in 1981 [Fed. Regist. 46(84): 24551–24553, May 1, 1981], and an initial decision reducing the tolerance for PCBs in fish and shellfish from 5 to 2 µg/g has been made [Fed. Regist. 47(46):10079–10080, March 9, 1982]. However, the decision is not final until the opportunity for submission of new information has passed. The analyses that follows are based on the conservative assumption that the FDA tolerance level for PCBs in fish of 2 µg/g will be adopted.

The mean concentration of PCBs (Aroclor 1254) in bluegill collected from South Hills Golf Course Pond (1.9 µg/g) is just below the proposed FDA tolerance level in fish of 2 µg/g, and four of the eight individuals had concentrations that were equal to or exceeded this level (maximum concentration = 3.8 µg/g, fresh wt). These levels

exceeded those found in bluegill from the upper reaches of East Fork Poplar Creek between New Hope Pond and Bear Creek Road (W. Van Winkle, ORNL, unpublished data). Concentrations of PCBs (Aroclor 1254) in bluegill (mean wt = 61.7 g) from this portion of EFPC ~~were~~ averaged 0.9 µg/g (range = 0.2–1.8 µg/g). Elevated levels were also found in a single turtle from South Hills Golf Course Pond, but concentrations in the small bullfrogs from the pond were all below the detection limit of 0.01 µg/g (Table 6). If PCBs accumulate in frog muscle tissue over time, as may occur with mercury (Table 5), then the small size range of the sample may acount for the similarity in PCB concentrations and the absence of any relationship between concentration and weight. Alternatively, frogs may be less exposed than fish to PCB contamination in the pond due to differences in diet, habitat preference, or respiratory physiology (i.e., direct uptake from water via gills in fish vs potentially limited uptake through the skin in the frogs).

Very low PCB concentrations, predominantly Aroclor 1260, were found in largemouth bass from Scarboro Pond ($\bar{x}$ = 0.02 µg/g; range = 0.01–0.03 µg/g). However, because PCBs do not occur naturally, any detectable level is an indication of contamination. Although no PCBs were found in the two frogs collected from the pond, no definitive conclusions can be drawn regarding levels of contamination in this species because of the small sample size. Likewise a larger sample of turtles from the other sites would be required before the risk to humans who consume them can be adequately evaluated. Because some turtle species may not reside in any one location for an extended period of time, they can have widely varied

Table 6

Table 6. Mean concentration of PCBs in muscle tissue of biota from various habitats in the vicinity of upper East Fork Poplar Creek. Less than value were ignored in computation of mean concentrations.

Site/species	Sample size (n)	Mean weight (g)	PCB ~~mercury~~ concentration (µg/g, fresh wt) Mean (±1 SE)	Range
Golf Course Pond (Station 1)				
Bluegill	8	85.8[a]	1.9[b,c]±0.4	0.25-3.8
Bullfrog	6	55.4	<0.01	all <0.01
Eastern painted turtle	1	425.	0.079[b]	-
Scarboro Pond (Station 2)				
Bluegill	2	78.4	<0.01	both <0.01
Largemouth bass	6	177.7	0.02[d]±0.01	<0.01-0.08
Bullfrog	2	53.4	<0.01	both <0.01
Tuskegee Creek (Station 3)				
Upper Tuskegee Creek (Station 3a)				
Red breast sunfish	1	70.1	<0.01	-
Snapping turtle	2	1810.5	0.85[b]	<0.01-0.17
Lower Tuskegee Creek (Station 3b)				
Creek chub	3	36.9	0.03[b]±0.02	<0.01-0.08
Red breast sunfish	2	126.8	0.10[b]±0.02	0.08,0.12
East Fork Poplar Creek (Station 4)				
Bullfrog	10	216.1	0.07[b,d]±0.02	<0.01-0.2
Snapping turtle	1	406.	0.06[d]	-
Crayfish	1[e]	9.6	<0.05	-

[a]Includes a bluegill x Lepomis sp. hybrid that weighed 395.2 g; excluding this individual, mean wt = 41.8 g and range = 29.5-67.8 g.

[b]Aroclor 1254.

[c]Does not include a 107.6 g bluegill collected from stream just below outlet of pond (~~mercury~~ PCB concentration = 0.81 µg/g, fresh wt).

[d]Aroclor 1260.

[e]Composite samples.

histories of exposure to contaminants. Consequently, a complete evaluation of PCB levels in turtles from the various sampling sites is not possible, given such small sample sizes.

Uranium

A limited number of aquatic organisms from four sampling sites were analyzed for isotopes of uranium. The concentrations of the isotopes in the organisms are listed according to sites in Table 7. Because of the sample size required for isotopic analysis (50 g) and the small size of the organisms available, many of the fish and frog samples are composite samples. A total of 16 samples were analyzed, with the organisms being more or less site specific. Only turtles and bluegill were analyzed from two sites. With the limited sample size, a comparison of concentrations in specific species between sites is not possible.

The concentrations of the isotopes of uranium in all the samples analyzed appears to be relatively low. Background levels for uranium in aquatic organisms from this area are not available. In most cases, the concentrations of ^{238}U are within a factor of two times the concentrations measured in fish from the Clinch River (Morrow 1977). Uranium does not readily bioaccumulate in fish. According to Blaylock (1982), the bioaccumulation factor for freshwater fish ranges from 0.3 to 135. This range is relatively low when compared with most fission products.

In all but three samples, the concentrations of ^{234}U and ^{235}U indicated that the isotopes were not in equilibrium with ^{238}U. In

Table 7. Concentrations of ^{238}U, ^{235}U, and ^{234}U in aquatic organisms

Date collected	Type sample	Concentration (Bq/kg)[a] ^{238}U	^{235}U	^{234}U
		Golf Course Pond		
6/9/83	Bluegill (composite)	0.10±0.04	0.067±0.032	0.42±0.08
		0.14±0.05	0.097±0.042	0.28±0.07
		0.22±0.05	0.033±0.022	0.18±0.05
	Hybrid (sunfish)	0.058±0.035	0.060±0.037	0.23±0.07
		Scarboro Pond		
6/9/83	Largemouth bass	0.22±0.07	0.067±0.033	0.45±0.08
		0.13±0.05	0.077±0.037	0.32±0.08
6/10/83	Largemouth bass (composite)	0.15±0.09	<0.02	0.14±0.08
6/9/83	Bluegill (composite)	0.16±0.09	0.073±0.047	0.22±0.10
		Tuskegee Creek near Tuskegee Drive		
6/9/83	Turtle	0.23±0.10	0.22±0.10	0.57±0.15
6/13/83	Turtle	0.065±0.065	0.012±0.014	0.22±0.12
		East Fork of Poplar Creek below New Hope Pond		
6/10/83	Frog (composite)	0.25±0.08	0.098±0.05	0.50±0.12
		0.22±0.07	0.20±0.07	0.53±0.12
6/10/83	Frog	0.18±0.07	0.083±0.051	0.53±0.13
		0.12±0.05	0.042±0.027	0.35±0.08
		1.7±0.2	0.23±0.08	3.3±0.3
6/14/83	Turtle	0.35±0.13	0.37±0.13	0.98±0.22

[a]Error terms are counting uncertainties only at 95% C. L.

Table 7

other words, the uranium is not from a natural source but appears to been enriched in ^{234}U and ^{235}U as the result of human activities. One composite sample of bluegill from the South Hills Golf Course Pond and two composite samples (one bluegill and one largemouth bass) from Scarboro Pond had isotopic ratios that indicated the uranium was from natural sources.

The highest concentration of uranium isotopes was detected in a bullfrog in the East Fork Poplar Creek below New Hope Pond. The concentration of ^{238}U was 1.7±0.2 Bq/kg and 3.3 ± 0.3 Bq/kg for ^{234}U (Table 7). This appears to be an anomalously high value (T7) comparable to tissue concentrations in fish from ORNL Pond 3513, the former low-level radioactive waste settling basin for ORNL; (J. R. Trabalka, personal communication). Assuming that an individual eats 20 g of frog legs/d for 365 d, the 50-year dose commitment is about 0.16 mrem for total body, 0.31 mrem for bone, and 0.7 mrem for kidney (Dunning et al. 1978). This is a very low dose commitment which is well within the variability of background radiation dose to man in the United States.

4. CONCLUSIONS

1. Levels of PCBs in bluegill from South Hills Golf Course Pond exceeded 2.0 µg/g, the proposed revision in the tolerance level for PCBs in fish recommended by the FDA and were twice the levels reported for bluegill in East Fork Poplar Creek below New Hope Pond.

2. Levels of mercury above 1.0 µg/g were found in the samples of bullfrogs and crayfish from upper East Fork Poplar Creek near Bear Creek Road, but additional information is needed on the form of mercury (organic vs inorganic) in biota other than fish to fully evaluate the impact from human consumption of these organisms.
3. Additional samples are needed before any assessment can be made of Hg and PCB contamination in turtles.
4. Mercury levels in axial muscle of bluegill from South Hills Golf Course Pond and Scarboro Pond and largemouth bass from Scarboro Pond did not exceed the FDA "action level" for mercury in the edible portion of fish 1.0 µg/g, fresh wt, but all individuals had mercury concentrations that exceeded background levels.
5. Mercury levels in several fish species from lower Tuskegee Creek were less than the FDA limit but were above background concentrations, suggesting that localized movements of fish may occur between East Fork Poplar Creek and its tributaries.
6. Although PCBs were not detected in small bullfrogs from South Hills Golf Course and Scarboro ponds, additional sampling of larger frogs should be conducted, especially in Scarboro Pond.
7. Levels of PCBs in largemouth bass from Scarboro Pond were only slightly above the detection limit of 0.01 µg/g.
8. A significant ~~regression of~~ log-log regression of mercury concentrations vs weight was observed in bullfrogs from East Fork Poplar Creek, suggesting that the accumulation of mercury with size/age that is typical of many fish species may also exist for other biota.

9. The relationship between PCB concentrations in axial muscle and fish size/age should be examined further in South Hills Golf Course Pond.

10. The number of samples analyzed for uranium isotopes was very limited. The sample size was not sufficient to allow for site comparisons between similar organisms.

11. In the majority of samples from all sites, the concentrations of ^{234}U and ^{235}U relative to ^{238}U indicated that the isotopes were not at equilibrium; thus, indicating that the uranium probably has been enriched. However, additional sampling and, in particular, mass spectrometric analyses should be conducted to confirm isotopic concentrations.

12. The highest concentrations of uranium isotopes were detected in one frog in the East Fork Poplar Creek below New Hope Pond. Even assuming that this value is accurate, an estimated dose commitment to man from consuming the frogs would be very low and well within the dose received from natural background.

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